DISTRIBUTION AND HOST-SPECIFICITY OF A NUMBER OF FLEAS COLLECTED IN SOUTH AND CENTRAL KENYA

(Including the Collection of the University College, Nairobi, Mount Kenya Expedition, March 1966)

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During the years 1963–1966 a collection of fleas was made by various members of the Department of Zoology of University College, Nairobi (UCN). This collection was mainly based on Dr. J. B. Foster's trapping of small mammals, and on the fieldwork of Dr. J. B. Sale with hyrax. Some specimens, however, were collected occasionally from road kills and other incidental mammalian hosts. The collection culminated with the work of the University College Mount Kenya Expedition in March 1966. The collection was mounted and identified by members of the Division of Insect-Borne Diseases (DIBD), Medical Department, Kenya, and a number of specimens were sent to Mr. F. G. A. M. Smit, Zoological Museum, Tring, England, for confirmation of identification.

The present records of distribution and host-specificity are of interest for a variety of reasons. Fleas only spend their adult life in intimate contact with the mammalian host, the larva is a free living insect, feeding on proteinaceous detritus. It is, therefore, to be expected that fleas will be mainly found on those mammals which have permanent dwelling sites, and particularly on nest or den building animals. This is the immediate effect of the need of a freshly emerged adult flea to contact a new host. Flea eggs deposited in a nest or den have a much higher chance of developing into adults within the immediate reach of a new host than flea eggs deposited at random in the field. One other consequence of this necessity of the flea to locate a host within its life time after larval development away from the host, is a dependence on the climate.

It is, thus, to be expected that within the fairly narrow geographical confines of Kenya a number of flea species will be restricted to particular altitudinal levels in response to a climatic adaptation, even when suitable hosts are available at other altitudes. Alternatively, one would expect to find fleas restricted to particular hosts at one altitude, and to other hosts at another altitude, this in response to the combined effect of climate and nesting habits of different hosts. This form of ecologically based isolation could well become the basis of speciation.

The Collection

The following species were collected and identified:

Chimaeropsylla potis potis
Ctenocephalides felis strongylus
Ctenophthalmus cophurus
Ctenophthalmus lycosius
Delopsylla crassipes
Dinopsyllus longifrons
Dinopsyllus lypusus
Echidnophaga aethiops
Nosopsyllus incisus
Procaviopsylla procaviae
Xenopsylla cheopis
Xiphiopsylla hyparetes
Xiphiopsylla levis

For each species a number of notes concerning distribution, ecology and host specificity are of significance.

In the following account all names of mammalian hosts in the paper follow Allen (1939) and the following symbols refer to location of specimens.

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1. *Delopsylla crassipes* Jordan, 1926a; (Pulicidae).

This species of flea is only known from the Kenya Highlands with previous records from the Nairobi and Nakuru areas. It is only known from the springhaas, *Pedetes surdaster* Thomas.

In February 1964, Foster collected one hare, *Lepus capensis* Linnaeus, and two springhaas in a small area on the Kapiti plains to the S.E. of Nairobi. From the springhaas 2 ♂♂‡ and 3 ♀♀‡ of *Delopsylla crassipes* were collected, from the hare 1 ♀† only. This record of *D. crassipes* on a hare is not necessarily an indication of this flea selecting the hare as a host. Several other hares have been collected in areas nearby, but not within a springhaas colony; on these hares, fleas were usually encountered, but never *D. crassipes*. It is therefore likely that this flea is indeed a highly host-specific species, which is merely carried temporarily by other furry hosts such as the hare.

2. *Echidnophaga aethiops* Jordan & Rothschild, 1906; (Pulicidae).

This flea is well known as a bat flea, associated mainly with the bat genus, *Nycteris*. It has been collected over a wide area of South and Central Africa (South Africa, S.W. Africa, Somalia and the Tsavo region of Kenya) (Jordan & Rothschild, 1906; 1913; Hopkins & Rothschild, 1953), but is not common.

In January 1964, Foster collected a bat, *Nycteris thebaica* Geoffroy, at Olorgesailie, approximately 45 miles S.W. of Nairobi in the Rift Valley. The fleas (8♀♀)† were restricted to the inside of the ear where they were attached by their proboscis to the membranous skin of the bat. The location and host fit very well within the previously recorded area for this flea. It seems likely, therefore, that *E. aethiops* is exclusively a bat flea and restricted to the genus *Nycteris* in the arid regions of Southern and Eastern Africa. On the basis of this single collection, it is impossible to attach any significance to the sex ratio (8♀♀, no ♂♂). Other collections have, on the whole, also had a very much larger number of ♀♀ than of ♂♂ (de Meillon, Davis & Hardy, 1961).

3. *Xenopsylla cheopis* (Rothschild), 1903; (Pulicidae).

This species is known from the entire world, including Australia and many oceanic islands (Hopkins & Rothschild, 1953). It parasitizes a large number of rodents including *Rattus rattus* (Linnaeus), which may well be the reason for it being found on so many islands. It is most likely correct to think of this species as a rodent flea, although it has been collected from such animals as genet, shrews, and man, but these records could easily be interpreted as stray specimens being temporarily harboured by non-host mammals which live in close proximity to one of the real hosts.

In February 1964, Foster collected two small rats, *Grammomys surdaster* (Thomas & Wroughton), at the foot of Lukenya Hill (20 miles S.E. of Nairobi) on which one ♀† and 2 ♂♂† of *X. cheopis* were found. Among the hosts listed in the literature (Hopkins & Rothschild, 1953) *Grammomys* is not listed, and is probably a new record. It is, of course, not at all surprising, as *X. cheopis* is known from a large number of small rodent species.

4. *Procaviopsylla procaviae* (C. Fox), 1914; (Pulicidae).

All records of this species of flea are from the elevated regions of Kenya and Tanzania, and all but one are from *Procavia* spp. or *Heterohyrax* spp. (Fox, 1914; Jordan, 1925; 1926b). One isolated record from a dikdik, *Rhynchotragus kirki* (Günther), may well be an example of a non-host carrier (Hopkins & Rothschild, 1953). It is, however, interesting to note that the dikdik is, like the hyrax, a small ungulate.

On two occasions (Feb. 1964 and Dec. 1965), Sale captured a number of specimens of *Heterohyrax syriacus* (Schreber) on Lukenya Hill (20 miles S.E. of Nairobi). On both occasions fleas were found on all or some of the hyrax, and a representative collection was made (26♀♀ and 13♂♂)‡. All specimens were identified as *P. procaviae*.

The present records confirm the opinion that *P. procaviae* is most likely a highly host-specific species restricted to a rather small geographical area and to a limited altitudinal range, in that on several hyrax collections from Mt. Kenya no fleas were encountered.

5. *Ctenocephalides felis strongylus* (Jordan), 1925; (Pulicidae).

This generally common species of flea is known from nearly all regions of Africa south of the Sahara and from several islands of the Indian Ocean. It is mainly known from low lying areas, but some records exist from highland areas in East Africa. It appears to be highly non-selective in host choice; records exist for many different species: several groups of predators, ungulates including hyrax, primates including man, rodents, insectivores and lagomorphs (Hopkins & Rothschild, 1953).

On the hare, *Lepus capensis*, collected in the springhaas colony on the Kapiti plains which harboured one specimen of *D. crassipes*, were found 2 ♂♂† and 3 ♀♀† of *C. felis strongylus* Of this latter species of flea, 1 ♂† and 1 ♀† were found on one of the springhaas, *Pedetes surdaster*, as well. It is impossible to determine whether the springhaas was a host or a carrier of *Ctenocephalides*. The very general host selection, however, would suggest that *Pedetes* could be considered as a host. A further 6 ♂♂† and 8 ♀♀† of *C. felis strongylus* were collected from a hare, *Lepus capensis*, in Nairobi National Park in March 1964, 7 ♂♂† and 5 ♀♀† from the rat, *Cricetomys gambianus* Waterhouse, which died after being in captivity for two years in Nairobi, 1 ♀* only from the rat, *Lophuromys aquilus* (True), collected by Foster on March 1, 1964 at 10,000′ altitude on the Aberdare Range, 1 ♂† and 31 ♀♀† from a hedgehog, *Atelerix pruneri* (Wagner), collected in 1960 in Nairobi, 1 ♀† only from an elephant shrew, *Petrodromus sultan* Thomas, collected by Foster on March 17, 1964 on Mrima Hill (30 miles S.W. of Mombasa), 1 ♀† from a zorilla, *Ictonyx striatus* (Perry), and 3 ♀♀† from another

zorilla, both collected on Lukenya Hill in February 1964, 1 ♂† and 3 ♀♀† from a civet, *Civettictis civetta* (Schreber), collected on March 5, 1964 near Langata, Nairobi and 1 ♂† and 7 ♀♀† from a live domesticated African bush cat, *Felis lybica* Forster, in Nairobi, in April 1964. The artificial conditions under which *C. felis strongylus* was collected from *Cricetomys* makes this record highly suspect. The collection from the Aberdares is the highest altitude record for this species. It is of interest to note that *Ctenocephalides* was not encountered on Mount Kenya among the collections made at 12-14,000′ altitude. Both rodent genera *Cricetomys* and *Lophuromys* are previously known as host genera. The hedgehog does not seem to be listed in the literature as a host, but this may well be a technical omission. The collection from zorilla, civet and bush cat fall completely within the main host range of this species of flea. The elephant shrew, *Petrodromus sultan*, is likely a new host record, although a different elephant shrew, *Macroscelides tetradactylus* (Peters), is known as a host, and *C. felis felis* is known from *Petrodromus* on the Kenya coast (Hopkins & Rothschild, 1953). This last record is in itself of interest. It seems hard to imagine that *C. felis felis* and *C. felis strongylus* would occur sympatrically and on the same hosts. This casts doubt on the subspecific status of these forms. Only a careful analysis of all previous records and possibly breeding experiments could decide on the status of these two forms.

6. *Nosopsyllus incisus* Jordan & Rothschild, 1913; (Ceratophyllidae).

A relatively rare species, known from a small number of rat-like rodents from elevated areas in East and Central Africa (Hopkins, 1947).

During the Mt. Kenya expedition of March 1966, two dormice, *Clavigilis murinus* (Desmarest), were collected in the upper Kazita West valley, carrying fleas of this species. One, at 12,500′ altitude carried 2 ♀♀* and the other at 13,500′ carried one ♂*. It is quite obvious that at this extreme altitude *Nosopsyllis incisus* is restricted to *Clavigilis*, other rodents collected in the same area carried other species of flea, but not *Nosopsyllus*. The dormouse is a new host reocord, and previously, *N. incisus* has not been collected over 10,000′ altitude. It is interesting that this species of flea is found on, for instance, *Lophuromys* at lower altitudes, but was not found on this rat at higher altitude. Perhaps nesting habits of different rodents restrict the host specificity of *Nosopsyllus* at high altitudes.

7. *Xiphiopsylla levis* Smit, 1960; (Xiphiopsyllidae).

This is a typical high altitude species known from small rodents on Mts. Elgon and Kenya, the Aberdares and from the Eastern Congo.

During the Mt. Kenya expedition, this flea was encountered as one of the commoner ectoparasites of the very abundant groove-toothed rat, *Otomys orestes* Thomas, at all sites in the upper Kazita West valley between 12,000′ and 14,000′ altitude. It did, however, show no distinct host specificity, being also collected from other small rodents and one specimen from a shrew. The details of the collected specimens being: 3 ♀♀* from an *Otomys orestes* trapped on March 20, 1966 at 12,500′ altitude, 1 ♀* from an *O. orestes* trapped on March 21, 1966 at 13.500′ altitude, 1 ♂* from another *O. orestes* trapped on March 21, 1966 at 13,500′ altitude, 1 ♂* and 1 ♀* from a dormouse, *Clavigilis murinus*, trapped on March 21, 1966 at 13,500′ altitude, 1 ♀* from a climbing rat, *Dendromus insignis* Thomas, trapped on March 23, 1966 at 13,500′ altitude, and 1 ♀* from a shrew, *Crocidura turba* Dollman, trapped on March 28, 1966 at 12,500′ altitude.

The above records strengthen the opinion that *X. levis* is a high altitude flea of small rodents. *Clavigilis* and *Dendromys* are new host genera. The record of one specimen collected from a shrew must be regarded with suspicion, especially since the shrew was briefly in contact with an *Otomys* after being killed.

8. *Xiphiopsylla hyparetes* Jordan & Rothschild, 1913: (Xiphiopsyllidae).

This rare species of *Xiphiopsylla* is also a high altitude flea, but is not known from extreme altitudes. It is only recorded from Kenya (Aberdares and Keruguya) and Eastern Congo. The only hosts on record are *Lophuromys* and *Rattus* (Jordan & Rothschild, 1913; Hopkins, 1947).

On March 1, 1964, Foster collected one ♂* of this species on a *Lophuromys aquilus* trapped on the Aberdares at 10,000′ altitude. It is significant that with so few previous records for this flea the one new record is from both a known location and a known host, strongly suggesting a very limited range and host selection.

9. *Chimaeropsylla potis potis* Rothschild, 1911; (Hypsophthalmidae).

The only hosts known for this flea are elephant shrews of the genera *Rhinonax* and *Rhynchocyon*, and its distribution is limited to Malawi and the East African coastal strip (Hopkins & Rothschild, 1956).

In March 1964, Foster collected 2 ♂♂‡ and 1 ♀‡ from a freshly killed elephant shrew, *Petrodromus sultan*, on Mrima Hill, 30 miles S.W. of Mombasa. This record strengthens the opinion that *C. potis potis* is a highly host specific flea, restricted to elephant shrews.

10. *Ctenophthalmus lycosius* Jordan & Rothschild, 1913; (Hystrichopsyllidae).

This flea is very rare; only few records are available. It is only known from the Aberdares and Mt. Kenya, previously collected between 6,000′ and 11,000′ altitude (Hopkins & Rothschild, 1966).

The rats, *Lophuromys flavopunctatus* Thomas, and the shrew, *Crocidura fumosa* Thomas, are known as hosts.

During the Mt. Kenya expedition, the flea was collected three times, all from *Otomys orestes:* 2♂♂‡ on March 21, 1966 at 12,500′ altitude, one further ♂‡ on March 21, 1966 at 12,500′ altitude, and 2♀♀* on March 23, 1966 at 13,500′ altitude. It is interesting that this flea was not encountered on either *Lophuromys* or *Crocidura*, both species being present in the same collecting area.

11. *Ctenophthalmus cophurus* Jordan & Rothschild, 1913; (Hystrichopsyllidae).

As the previous species, this one has a very restricted distribution in East Africa, is known from high elevations only, but has previously been collected from a variety of small rodents.

Two collections of this flea were made during the March 1966 Mt. Kenya expedition: 1♂‡ and 3♀♀‡ from *Crocidura allex* Osgood and 1♂‡ from the moleshrew, *Surdisorex polulus* Hollister, both at 12,500′.

It is of interest that both of these records are from insectivore hosts, and that none of the rodents (including *Lophuromys*) that were trapped on the alpine zone of Mt. Kenya carried this species of flea.

12. *Dinopsyllus longifrons* Jordan & Rothschild, 1913; (Hystrichopsyllidae).

This is also a highland species. It is somewhat better known than both *Ctenophthalmus* species. Its range covers most elevated areas of East Africa, Congo, Zambia and Malawi. As hosts are listed several species of *Otomys* and a few other rodents.

During the March 1966 Mt. Kenya expedition, this flea was found on nearly all specimens of *Otomys orestes* collected. It was encountered at all elevations between 12,000′ and 14,000′ altitude. A total of 17♀♀‡ and 11♂♂‡ were collected, of this common flea in the Kazita West valley.

It is particularly interesting to note that despite its relative abundance on *Otomys* this flea was not found on any other animal. Such extreme host specificity has not previously been reported for this species, and may well be the result of the extreme conditions of the alpine zone.

13. *Dinopsyllus lypusus* Jordan & Rothschild, 1913; (Hystrichopsyllidae).

This fairly common species is widely distributed throughout East and Central Africa, and is known from a wide variety of small rodents. One ♀† was collected from a small rat, *Grammomys surdaster*, which was trapped on Lukenya Hill (20 miles S.E. of Nairobi) in February 1964 by Foster.

DISCUSSION

The danger of considering any animal carrying a flea the host of that particular flea is well illustrated in the case of *Delopsylla crassipes*, which is obviously a highly host specific flea, restricted to the springhaas, *Pedetes surdaster*. It was, however, also found on the hare, *Lepus capensis*, but only on those hares which live within the confined area of a springhaas colony. Similarly, *Xenopsylla cheopis*, *Xiphiopsylla levis* and *Ctenophthalmus lycosius*, all three typical rodent fleas have been collected from man, small predators and shrews. Again, the non-rodent records are most likely of strays, even though *X. cheopis* is known to bite man, and thus become a possible distributor of plague. On the other hand, the record of a flea on a vertebrate other than its normal host(s) does not necessarily mean that it is a stray. This situation is well illustrated by *Ctenophthalmus cophurus*, which although listed as a rodent flea, has been collected from two species of shrew. The relationship between rodents and shrews is remote, and yet, there appears a considerable overlap of rodent and shrew use for a number of flea populations. The extent of the overlap is such that accidental straying and carrying seems most unlikely, especially since some other species, such as *Dinopsyllus longifrons* and *Nosopsyllus incisus* have been found in relatively large numbers on rodents, but not at all on shrews. Could it be possible that those rodent fleas found consistently on shrews in certain locations (like the alpine zone of Mt. Kenya) are in fact evolving very rapidly in response to the extreme environment? It could be hypothesized that certain species of rodent flea take advantage of a shrew population for dispersal purposes, but under normal conditions it is not of selective advantage to derive blood from the shrews or breed in shrews' nests. Under special conditions of the alpine zone, however, this balance may be upset, and some flea species could evolve so as to switch completely and become exclusively host specific for shrews. The flea, *Ctenophthalmus cophurus*, illustrates this situation. The subspecies, *C. c. cophurus*, is known only from rodents at altitudes between 6,000′ and 11,000′ in the Kenya and Uganda highlands, *C. c. hemmingwayi* is also from rodents at similar altitudes, but in the Kilimanjaro region. The specimens of *C. cophurus* from the alpine zone of Mt. Kenya were all collected from shrews, none were encountered on the large sample of the rodent population. It seems likely that these latter specimens represent a new subspecies in a stage of development, where they can not yet be recognized morphologically, but where they are a completely isolated population as a result of their regional host specificity.

The nesting ecology of rodents and shrews in the extreme climatic conditions of the alpine zone of Mt. Kenya is as yet not known. In order to understand the host (and carrier) selection of fleas in this region much more will have to be learned concerning the small mammals. One glimpse into this field is provided by the records of the flea, *Nosopsyllus incisus*, which was found on Mt. Kenya restricted to the dormouse, which builds an elaborate nest, while at lower elevations the same flea is found on other rodents as well. It appears plausible that it is only the nesting habit which at the climatic conditions of the alpine zone restricts *N. incisus* to the dormouse.

As illustrated in *N. incisus* and *C. cophurus*, the combination of climatic conditions and the nesting habits of small mammals result in increased host specificity of fleas. This will be a more or less effective isolation of fairly small, altitude restricted, populations. This, in turn, could lead to genetic variation and speciation. Indeed, evidence is available for such localized speciation. *Procaviopsylla procaviae* is found only to the south of Nairobi, while on the Ngong Hills and further north a very close, but distinct species *P. isidis* is found (Hopkins, 1947). Hopkins & Rothschild (1966) consider *Dinopsyllus longifrons* a fluid species, only "typical" at altitudes above 10,000′ in East Africa. Records from lower altitudes (6,000′–10,000′) appear to differ sufficiently to warrant a sub-specific separation. They further consider *D. lypusus* of lower altitudes yet another sub-species of the same group, and *D. tenax* of South Africa is possibly a very recent offshoot of ths group as well. It is of interest to note that here, like in *C. cophurus* and *N. incisus*, the high altitude (i.e. over 10,000′)collections are much more host specific than the lower altitude collections.

Finally, one problem must be mentioned. A number of species appear to be restricted not to one small high altitude region, but to a number of rather widely separated, completely isolated regions such as Mt. Kenya, Mt. Elgon, and the Ruwenzori. A number of explanations are possible. Perhaps the isolation is far less effective than our collecting records suggest, or alternatively the adaptive evolution to high altitude conditions has proceeded along so closely resembling parallel lines, that the results are morphologically indistinguishable and thus considered as one species. The earlier discussed evidence of recent speciation would render unlikely, but not rule out entirely, yet another hypothesis: that we are dealing with non-plastic relic species. It is obvious that much more can be learned when further collections (especially at varying altitudes) are made and analysed in the future. It would also be very worthwhile to make a more detailed study of the entire population ecology of a number of flea species, together with a study of their hosts.

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